Geological mapping of a simple crater: Case study of Lichtenberg B. I .Varatharajan[1] and U. Sruthi[2], [1]Institute for Planetary Research, German Aerospace Center DLR, Rutherfordstr. 2, Berlin–Adlershof, Germany (indhu.varatharajan@dlr.de), [2]Centre for Earth Evolution and Dynamics, University of Oslo (sruthi.uppalapati@geo.uio.no),

Introduction: Simple craters on the Moon are simple bowl-shaped products of impacts on the surface with diameters generally ~<15km and having a depth/diameter ratio of about 1:5 [1]. Studying these craters to their structure, geometry, morphology, and mineralogy [2,3] helps us to understand the early stage modification processes on simple craters on earth and other planetary surfaces. Current study involves the case study of a simple crater, Lichtenberg B, with both the morphological and mineralogical approach where the inferences shall result in the understanding of structural evolution in simple crater formation. Lichtenberg B has a diameter of ~5 km located at 33.25^{o}N, 61.52^{0}W. It is a fresh lunar crater on the mare basalt unit dated to be ~1.68 Ga [4] in Oceanus Procellarum. This ~5 km diameter crater preserves various morphological features including melts, fractures, boulders, slumping of wall, and detailed ejecta morphology. The depth to diameter ratio of the crater is measured to be 0.217. The bright ejecta pattern with wrinkled symmetrical cresent ridges, the rock outcrops in the crater wall showing the successive thin lava flows of Oceanus Procellarum as old as ~3 Ga, the crater floor polygons, well preserved crater morphology details makes an ideal candidate for the study of small, fresh lunar craters.

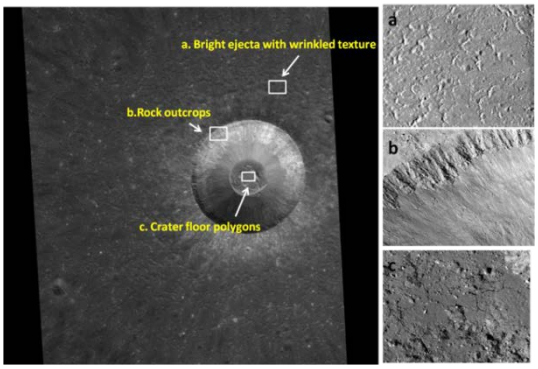

Figure 1. LROC NAC image of Lichtenberg B showing the details of a) wrinkled bright ejecta, b) rock outcrops in the crater wall, and c) melt cracks in the floor.

Datasets: The Lunar Reconnaissance Orbiter (LRO) Narrow Angle Camera (NAC) datasets having ~0.5 m/pixel spatial resolution are used to map the morphological details of the crater [5]. The mineralogy of the morphological features is also investigated using the Chandrayaan-1 Moon Mineralogy Mapper (M3) hyperspectral datasets having spatial resolution of 140 m/pixel [6].

Analysis & Results: *Morphology:* Lichtenberg B crater stands out as one of the very few young craters with symmetrical cresent ridged unique ejecta pattern. The geologic mapping is carried out using ArcGIS 10.2.Fig 2. Shows the morphologic mapping of the crater which includes the mapping of crater materials like ejecta, floor, impact melts and wall materials. We also mapped the structural features formed from the crater formation such as concentric faults covered partially by the melt flows at places. Bright rays of the ejecta, extending upto ~30 km and continuous ejecta with concentric cresent ridges extends to ~10 km. The crater floor is filled with smooth melt pooling with cracks and clusters of fallback rock fragment mounds. Along the rim of the crater, SW-E there are impact melt flows observed. This might indicate the impact direction resulting in absence of melt ponds on the uprange direction. The crater wall exposes a minimum of five lava flows (Fig. 1b), modified by mass wasting with loose and fine grained material flows. The topmost layer of this flow measured in this study is calculated to be within the layer width of ~35-45 m (measured at various transects along the flow) which is comparable to the proposed late stage lave flow thickness of ~30-60 m in Oceanus Procellarum. These flows covers the wall and are distributed uniformly possibly suggests the late modification of crater wall material collapse. The crater is populated with boulders of varying sizes with average upper size range of ~30-35 m.

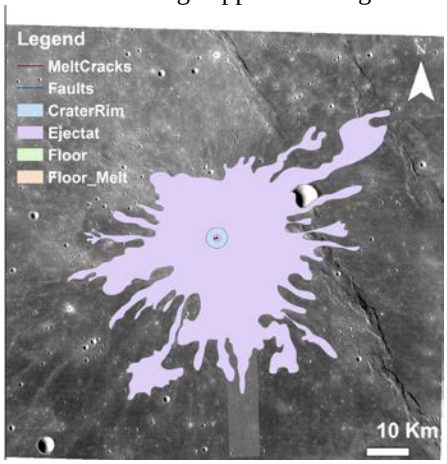

Figure 2. Geologic map of Lichtenberg B crater

Crater Counting age: In addition to the geologic mapping, crater counting for the absolute model age of

the crater has been carried out using cratertools plugin [7] in ArcMap 10.2 and craterstats2 [8] on the ejecta surface to the east of the crater as shown in Fig. 3a. The counting area for mapping has been chosen based on the uniform distribution of ejecta and slope. The total of 884 craters of diameters ranging from 8- 65 m in an area 45.285 km^2 are plotted using craterstats.Crater Size-Frequency Distribution (CFSD) plots displaying crater size versus frequency over lunar geologic time including isochrones are plotted for the mapped crater statistics resulting an absolute model age of Lichtenberg B as ~17.9±0.6 Ma (Fig. 3b).

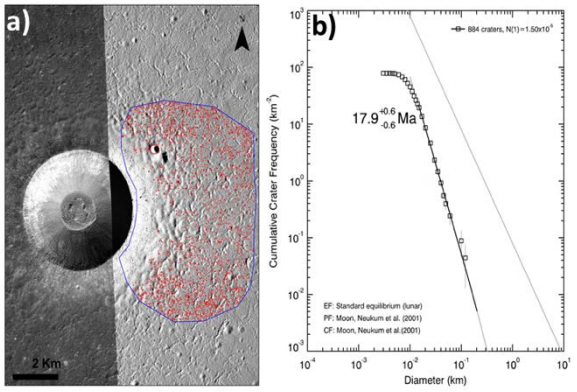

Figure 3. a) The areal extent of craters mapped using cratertools of ArcMap, and b) CSFD plot for the mapped crater statistics displaying the age of the crater.

Spectral studies: The M3 spectra from the selected crater units are analysed to assess the spectral heterogeneity among the various geomorphological features around the Lichtenberg B crater.The spectra from the crater wall shows strong absorption features whereas basalts show least spectral contrast inferring the freshness of the crater (~17.9 Ma).

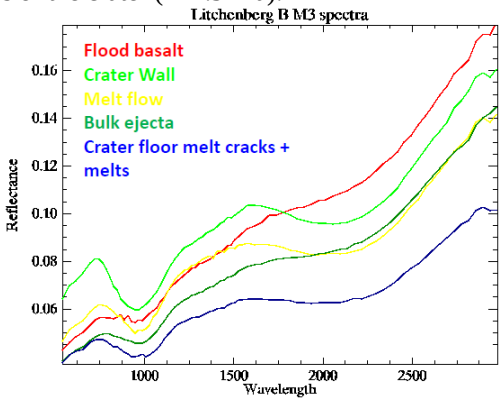

Figure 4. a) Reflectance spectra of the morphology units mapped

It is also important to note that Lichtenberg B is formed at the boundary of two lava flows in Oceanus Procellarum, namely P9 (~3.47 Ga) and P53 (~1.68 Ga) [4]. Therefore, the impact stratigraphy of Lichtenberg B can also possess the spectral nature from both the flow materials. This will be addressed in detail in further study. Apart from that, the spectral counterparts do not reveal distinctive spectral contrasts among the units mapped.

Discussion: Though terrestrial craters are studied in detailed through field geology, it is important to note that they have undergone continuous weathering throughout the Earth's history. Lonar crater on Earth is the only known terrestrial crater on basaltic terrain which is analogous to simple craters on Moon and Mars. It is formed in ~65 Ma old Deccan flood basalts at 19°58′N, 76°31′E, near Lonar village in Buldhana district of Maharashtra State in India. This crater is studied for its structural effects in target strata and impact fragmentation processes, however its initial impact structures may have been erased as the crater has been undergone continuous climatic/environmental weathering [9].

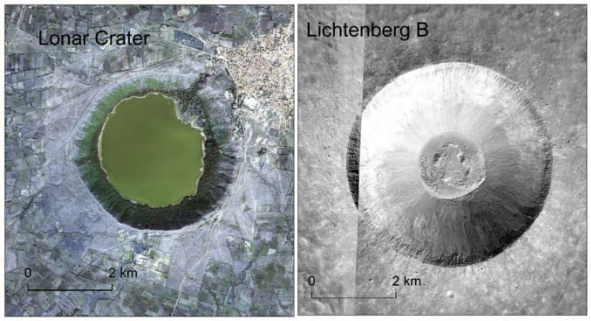

Figure 5. a) Quickbird extent map of Lonar crater, b) LROC NAC image showing Lichtenberg B (M1103959207RE).

Morphologically, Lichtenberg B is comparable to the Lonar crater as both are formed in the flood basalts in Oceanus Procellarum and Deccan plateau respectively (Fig 5.).The detailed mapping of both geologic and mineralogic units of Lichtenberg B will give us a window to understand the early impact scenario of Lonar crater. Thus the studies of Lichtenberg B and Lonar will improve understanding of the formation of simple craters in basaltic targets.

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